REMOTE-CONTROLLED, WORK-CAPABLE MINIATURE VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority to PCT Application Serial No. PCT/US01/ , for inventor Andrew W. Gordon, filed by DirtBilt, Inc., on October 26, 2001, which is incorporated by reference herein in its entirety.

NOTICE OF COPYRIGHT PROTECTION

A portion of the disclosure of this patent document and its figures contain material subject to copyright protection. The copyright owner has no objection to the facsimile reproduction by anyone of the patent document or the patent disclosure, but otherwise reserves all copyrights whatsoever.

FIELD OF THE INVENTION

The present invention relates in general to small-scale vehicles and in particular to remote-controlled, small-scale vehicles.

BACKGROUND

A variety of small, remote-controlled vehicles are available on the market. These vehicles are commonly radio-controlled "toy" vehicles, such as cars or trucks, which are built primarily for entertainment purposes. Such toy vehicles are not made to accomplish work and, therefore, do not include robust propulsion and accessory systems. In contrast, full-size machines designed to perform work have very robust propulsion and accessory systems.

For example, a small, tracked vehicle conventionally includes a small battery-powered motor driving a plastic or rubber track or may even include a hidden drive wheel, relegating the track to mere decoration. As a result, a small, tracked vehicle may be able to push only very small items, weighing much less than the vehicle itself. Also, the small vehicle may be able to traverse only minimal obstacles and may operate for a short period of time before requiring its batteries to be charged or replaced. Many conventional toy vehicles are powered by limited-life power sources. For example, a toy vehicle utilizing a nickel-cadmium power supply may have an elapsed running time of only ten to fifteen minutes.

In contrast, a larger tracked vehicle includes a powerful electric or combustion engine driving a metal track. A larger vehicle is capable of pushing very heavy objects and traversing substantial barriers. With large fuel tanks and/or battery packs, a larger vehicle is able to perform work for an extended period of time.

Accessory systems on small vehicles are designed primarily for form rather than function. For example, on a conventional toy bulldozer, the blade assembly is raised and lowered using a servo, battery-powered motor, and/or spring-driven mechanism. In contrast, a large, scale-size bulldozer utilizes a hydraulic system to raise and lower the blade.

Conventional small, remote-controlled vehicles appeal to individuals purchasing a model for entertainment. However, serious model enthusiasts, organizations wishing to use remote-controlled vehicles in hazardous situations, and others desire small-scale vehicles having more robust features and capabilities than conventional toy vehicles. Thus it would be advantageous to provide a small-scale, remote-controlled vehicle that is capable of performing work.

SUMMARY

Embodiments of the present invention provide miniature vehicles capable of performing work. One such embodiment of the present invention comprises a miniature vehicle that is a small-scale version of a full-size machine and that is remote-controlled. The miniature vehicle includes a working hydraulic system for manipulating attachments and a propulsion system having individually controllable metal tracks. The miniature vehicle is capable of performing work for recreational purposes, and commercial and law enforcement-related purposes, such as the work involved in dealing with hazardous materials or surveillance.

In embodiments of the present invention, a miniature vehicle comprises a frame, on which a propulsion system and a hydraulic system are mounted. The miniature vehicle comprises a first actuator to control the propulsion system and a second actuator to control the hydraulic system. The propulsion system may include a plurality of metal tracks, wherein each track comprises a plurality of metal links attached pivotally to the two adjacent links to form a continuous loop. The propulsion system includes a discrete control mechanism for each track. For example, in an embodiment of the present invention, a miniature bulldozer includes a separate control mechanism for each track so that turning the bulldozer is accomplished by varying the speed and/or direction of the individual tracks. The propulsion system includes a power source, such as a battery. In an embodiment of the present invention, a gel-cell, twelve-volt battery provides the vehicle with the advantage of a relatively long operating time. The propulsion system also includes an electronic speed control linked to a radio-control or other control system.

A hydraulic system in an embodiment of the present invention is similar to a brake system in an automobile, comprising a master cylinder in fluid communication with at least one

slave cylinder and forming a closed loop system. The hydraulic system includes a rack-and-pinion mechanism, which is attached to an input shaft of the master cylinder. Rotation of the pinion gear causes the rack to move and causes inward movement of the input shaft in the master cylinder. This inward movement forces hydraulic fluid through hydraulic lines to a slave cylinder. The hydraulic pressure caused by the fluid movement causes extension of an output shaft of the slave cylinder.

The pinion gear is rotated by an electric motor, which is connected to and activated by a toggle switch. The toggle switch is, in turn, activated by a radio-controlled servo. In embodiments of the present invention, a hydraulic system can utilize mineral oil as the hydraulic fluid. Mineral oil provides the advantages of being non-toxic and non-staining.

Embodiments of the present invention include a body, or shell, for a miniature vehicle. A body attaches to the frame and may be interchangeable with other bodies. For example, a bulldozer body can be interchanged with a tank body. Examples of bodies in other embodiments include a truck body or a crane body.

In an embodiment of the present invention, a miniature bulldozer includes a bulldozer blade. The bulldozer blade is connected to the hydraulic system so that the hydraulic system raises and lowers the blade. The bulldozer may also include a ripper arm. The ripper arm is also attached to the hydraulic system so that it may be raised and lowered.

Embodiments of the present invention include a wireless video camera, sensor, detector and/or sampling devices mounted directly or indirectly to the vehicle frame. Embodiments for use in a law enforcement or military capacity include weapons and detectors, such as land mine detection and/or pre-detonation devices.

An embodiment of the present invention provides advantages over conventional small, remote-controlled toy vehicles. These advantages include robust propulsion and hydraulic systems in a miniature, remote-controlled, scale-size vehicle. Such features provide advantages to the serious hobbyist, to organizations wishing to use remote-controlled vehicles in hazardous situations, and others.

One advantage of the present invention is that the robust propulsion system resembles that of a full-size machine and allows the vehicle to traverse terrain and obstacles beyond the capabilities of a less robust, remote-control vehicle. Another advantage is that a working hydraulic system closely reflects such a system in a full-size machine and allows the small vehicle to perform tasks that a toy vehicle cannot.

Embodiments of the present invention have the further advantage of reducing the safety risks encountered by police officers and military personnel in hazardous situations. For example, an embodiment including a video camera performs reconnaissance in a hazardous situation that would otherwise require the presence of a person.

Further details and advantages of the present invention are set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention are better understood when the following Detailed Description is read with reference to the accompanying drawings, wherein:

Figure 1 is a side perspective view of an embodiment of the present invention as a bulldozer.

Figure 2 is a side, rear view of the drive components in an embodiment of the present

invention.

Figures 3A, 3B, 3C, and 3D illustrate components of a track propulsion system in an embodiment of the present invention.

Figure 4 is a top perspective view of a hydraulic system in an embodiment of the present invention.

Figures 5A and 5B illustrate a ripper assembly in an embodiment of the present invention.

Figures 6A and 6B illustrate various shells for attachment to a frame in an embodiment of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention include a frame on which is mounted a propulsion system, including metal tracks, a hydraulic system, a power supply, and a control system. These aspects provide robustness to a miniature vehicle, allowing the vehicle to perform work. In an embodiment of the present invention, the control system is a remote-control system, such as a radio-control system, which provides an operator of the miniature vehicle the ability to operate the vehicle in remote locations.

Figures 1-6 illustrate various aspects of embodiments of the present invention as a small-scale version of a full-size vehicle, which is capable of performing work. FIG. 1 illustrates an embodiment of the present invention as a miniature bulldozer 120. Embodiments of the present invention comprise a frame to which other components may be mounted. The frame (not shown) comprises aluminum and/or some other material suitable for mounting various components of the machine.

A propulsion system is mounted on the frame of miniature bulldozer 120. The propulsion system comprises a pair of metal tracks 105a and 105b. A gear 107a drives track 105a. A series of rollers 109a-d guide the bottom portion of track 105a. The propulsion system further comprises a guide wheel 108 on which track 105a is seated.

Bulldozer 120 includes an actuator (not shown) for activating and controlling the propulsion system. For example, the propulsion system actuator on bulldozer 120 may include a remote-controlled electronic speed control. Alternatively, the actuator includes a pre-programmed, computer-controlled propulsion system actuator. The actuator controls tracks 105a and 105b individually, allowing the bulldozer 120 to execute turns by varying the speed and/or direction of tracks 105a and 105b.

Referring again to FIG. 1, bulldozer 120 also comprises a bulldozer blade assembly 110, 111 and a ripper assembly 112, 113. Blade 110 is rigidly connected to a blade arm 111, which is pivotally connected to the frame of bulldozer 120. Ripper 112 is similarly attached to the frame of bulldozer 120 via a parallelogram ripper arm 113. Both the blade 110 and the ripper 112 are operated with a hydraulic system mounted on or to the frame.

In the embodiment illustrated in FIG. 1, a hydraulic system includes hydraulic slave cylinders 101a, 101b, and 103. Slave cylinders 101a and 101b are in fluid communication with a first master cylinder (not shown). Slave cylinder 103 is in fluid communication with a second master cylinder (not shown). Slave cylinders 101a and 101b are further attached to blade arm 111 and operate to raise and lower blade 110. Slave cylinder 103 is attached to ripper arm 113 and operates to raise and lower ripper arm 113 and ripper 112.

In addition to a propulsion system actuator, bulldozer 120 also includes an actuator to separately control the hydraulic systems attached to blade 110 and ripper 112, respectively.

Similar to the propulsion system actuator, the hydraulic system actuator may include a remote-controlled system, such as a radio-controlled servo system.

The bulldozer 120 in FIG. 1 is robust and capable of performing work. For example, in experimentation, bulldozer 120 was found to be capable of pushing a cinder block, weighing over thirty-six pounds. Also, bulldozer 120 was found to be capable of pulling a wagon carrying in excess of fifty-five pounds.

Propulsion System

As described briefly above, an embodiment of the present invention comprises a propulsion system. The propulsion system includes wheels and/or tracks. FIG. 2 illustrates a track propulsion system in an embodiment of the present invention.

The track propulsion system shown in FIG. 2 comprises a pair of tracks 105a and 105b. Each of the tracks 105a, 105b is driven by a discrete control mechanism. Gears 107a and 107b drive tracks 105a and 105b, respectively, and are connected to matching drive systems. Gear 107a is attached coaxially to drive shaft 208. In the embodiment shown in FIG 2., gear 107a is attached at an outside end of drive shaft 208. In other embodiments, the drive gear 107a is attached at various positions along the length of drive shaft 208. Gear 202 is also attached coaxially to drive shaft 208 so that when gear 202 rotates, drive shaft 208 rotates as well. Rotation of drive shaft 208 causes rotation of gear 107a and a corresponding movement of track 105a. Gears 107a and 202 may be of the same or different sizes.

Gear 202 is engaged with gear 203. Gear 203 is coaxially attached to an output shaft (not shown) from motor 201a. The embodiment shown in FIG. 2 comprises a motor 201a. Motor 201a drives a single track. Various other embodiments of the present invention comprise a more than one motor, depending on the wheel/track design and degree of control desired. Motor 201a

provides sufficient power to perform work. In one embodiment of the present invention, the motor, such as motor 201a in FIG. 2, is a twelve-volt motor, which provides an amount of torque sufficient to allow the machine to push or pull heavy loads.

The machine shown in FIG. 2 also includes a speed control 205. The speed control 205 is attached to the motors 201a, b by electrical control wires 204a, b, respectively. Speed control 205 may comprise an electronic speed control, providing proportional and infinitely variable individual speed and directional control of motors 201a, b. For example, an embodiment of the present invention utilizes the Novak Super Rooster reversible digital speed control to distribute power to the motors.

The speed control is attached to various other components. For example, in an embodiment of the present invention, comprising a radio-controlled machine, the speed control is attached to a radio receiver. Attached to the radio receiver is an antenna that receives signals from a transmitter. The transmitter includes a right and a left joystick. When the right joystick is moved vertically forward or backward from a neutral and/or centered position, the joystick movement causes a corresponding movement in the right track of the machine. If both joysticks are moved forward or backward in unison, the machine moves forward or backward respectively. If the left and right joystick are moved in different directions or in differing amounts, the machine turns towards the track which is moving more slowly. For example, if the right joystick is pulled backward, causing the right track to reverse, and the left joystick is pushed forward, causing the left track to move forward, the machine turns to the right.

In other embodiments of the present invention, the speed control includes mechanical controls, such as toggle switches. The toggle switches are connected to miniature control

devices in the machine that are visible to a person observing the machine working. The movement of the control devices provides animation in an embodiment of the present invention.

In the embodiment shown in FIG. 2, gel-cell battery 207 is a power source that provides energy to the speed control 205 and motors 201a, b. The battery 207 is electrically connected to speed control 205 via a wire 206. In the machine shown in FIG. 2, a 12-volt gel cell battery has an operating time of approximately 2 to 6 hours between charges, depending on operating conditions and loads.

The track 105a shown in FIG. 2 comprises a plurality of metal links. Figures 3A-D illustrate an embodiment of elements of track 105a in separate views, the combination of elements of track 105a, and the interaction of elements of track 105a with drive and suspension systems of the present invention.

FIG. 3A is a side view of a track link 301a. Track link 301a comprises a pair of connectors, represented by connector 302a in FIG. 3A. As shown in FIG. 3C, the connectors 302a, b are mounted transversely to track link 301a and project beyond the surface of track link 301a.

FIG. 3C provides a perspective view of the link from above a surface of link 301a to which the connectors 302a, b are attached. Connector 302a is parallel to connector 302b and each is shaped so that the space between them is narrow at one end and wide at the other end. The narrow and wide ends of connectors 302a, b are complementary. The distance between the outside edges of the connectors 302a, b at the narrow end is less than the distance between the inside edges of each connector at the wide end, such that the narrow end may be inserted into the wide end of an adjacent link. The adjacent links are attached by various pivotal means, such as pins and rods.

FIG. 3D illustrates track 105a, comprising a plurality of links 301a-d so attached. As shown in FIG. 3D, once the links 301a-d have been pivotally attached, they functionally engage drive gear 107a. Once the links 301a-d are engaged with gear 107a, then when gear 107a rotates, track 105a moves, sliding along roller 109a with which track 105a is also engaged.

The tracks illustrated in Figures 3A-D may comprise various materials, including rubber, plastic, and/or metal. In a preferred embodiment of the present invention, the tracks are metal, and the metal is of sufficient hardness so as to resist galling. For example, the tracks may comprise stainless steel and/or other steel and steel composites. Alternatively, the links may comprise a relatively hard or zinc-anodized aluminum.

In an embodiment of the present invention as a front-end loader, the propulsion system comprises four wheels. Power is supplied to one or more of the four wheels by an electric motor, such as the motors shown in FIG. 2. Steering of a front-end loader is accomplished through use of differential speed to wheels on opposite sides of the machine and/or by the addition of a steering mechanism to the front or rear of the machine.

In an embodiment of the present invention as a tank, suspension elements are included in track 105a for greater realism and functionality.

<u>Hydraulic System</u>

An embodiment of the present invention comprises a hydraulic system for performing work. FIG. 4 illustrates the various components of a hydraulic system in an embodiment of the present invention. The hydraulic system shown in FIG. 4 operates the bulldozer blade 110, as shown in FIG. 1.

The hydraulic system shown in FIG. 4 is similar to a braking system in an automobile and comprises a master cylinder 409 as well as a slave cylinder 101a. Such a system is known as

a closed-loop system. In this closed-loop system, a constant volume of fluid is transferred back and forth between the master cylinder 409 and the slave cylinder 101a during operation of the hydraulic system. Mineral oil, which is non-toxic and non-staining, is advantageously utilized as hydraulic fluid in embodiments of the present invention.

Master cylinder 409 includes an input shaft 408. Movement of input shaft 408 causes a corresponding movement of a piston within master cylinder 409. Movement of the piston causes hydraulic fluid to be pressurized within master cylinder 409 on the side towards which the piston is moving. Master cylinder 409 is in fluid communication with slave cylinder 101a. When the input shaft 408 is moved inwardly in the master cylinder, fluid is forced out of the opposite end of master cylinder 409 through a valve or fitting 410a into hydraulic line 412a.

Slave cylinder 101a includes a fitting 410b at one end, which is attached to hydraulic line 412a at an end opposite the master cylinder 409. The pressure of the fluid exiting master cylinder 409 causes the fluid to flow through hydraulic line 412a and enter slave cylinder 101a through fitting 410b. This movement of hydraulic fluid into slave cylinder 101a causes a piston (not shown) inside slave cylinder 101a to move in the direction opposite fitting 410b. Attached to the slave cylinder piston is an output shaft 411. Movement of the piston causes a corresponding movement of output shaft 411. Thus, when hydraulic fluid enters slave cylinder 101a at one end of slave cylinder 101a, output shaft 411 moves outwardly from the opposite end of slave cylinder 101a. Movement of the slave cylinder piston forces hydraulic fluid to exit slave cylinder 101a at fitting 410d and enter hydraulic line 412b. The fluid then flows through hydraulic line 412b and enters master cylinder 409 at fitting 410c.

Therefore, a control force exerted on input shaft 408 causes a corresponding, opposite movement of output shaft 411. An inward movement of input shaft 408 causes a corresponding

outward movement of output shaft 411. Likewise, outward movement of input shaft 408 causes inward movement of output shaft 411.

The output shaft 411 is functionally connected to a bulldozer blade assembly, including blade 110 and blade arm 111. Output shaft 411 is attached to blade arm 111, which is attached to the vehicle frame. Blade arm 111 is also attached to blade 110. In the embodiment shown in FIG 4, an outward movement of output shaft 411 causes blade 110 to lower. An inward movement of output shaft 411 causes blade 110 to rise. It is known that hydraulic fluid does not compress. Therefore, once the blade 110 is lowered, the blade 110 will not rise unless a force is applied to the blade 110 and/or output shaft 411 that is greater than either the force that the weight of the miniature bulldozer is applying downward on the blade 110 or the amount of force the hydraulic system is capable of withstanding before failure.

For example, in the embodiment shown in FIG. 4, the hydraulic lines 412a, b and the fittings 410 a-d on the master cylinder 409 and slave cylinder 101a are capable of providing hydraulic pressure in excess of 150 pounds per square inch (PSI). The force the machine is capable of exerting through the hydraulic system is calculated using the formula, Force = $(1 / (r_{piston}^2 * \Pi)) *$ Machine Weight, where r_{piston} is the radius of the piston in inches and Machine Weight is the weight of the machine in pounds. In the embodiment shown in FIG. 4, the radius of the piston is 0.3125 inches and the machine weights 39 pounds. Applying this formula to the embodiment shown in FIG. 4 ((1/(0.3125 * 3.1417) * 39 pounds) shows that the machine is capable of exerting a force of approximately 127 PSI.

In the embodiment shown in FIG. 4, the input shaft 408 of master cylinder 409 is moved using a rack and pinion system. An end of rack 404 is attached to input shaft 408. Along one side of rack 404 are teeth. The teeth in rack 404 are transversely engaged with gear 402. To

ensure that rack 404 remains engaged with gear 402, rack 404 rolls along roller 401 on the side of rack 404 opposite gear 402.

The gear 402 is coaxially attached to an output shaft of an electric motor (not shown). When the electric motor operates, it rotates gear 402. The electric motor is electrically connected to a switch 407. The switch 407 is connected to and controlled by a servo 406. Battery 207 is connected to and provides power for both servo 406 and, via switch 407, the electric motor that operates pinion gear 402. A limiter 403 is connected to the electric motor to stop the motor when input shaft 411 reaches its limit of inward or outward movement from master cylinder 409.

Embodiments of the present invention further comprise a radio receiver connected to the hydraulic system for remote operation of the hydraulic system. In various embodiments, the hydraulic system powers various types of accessories, such as ripper arm 112 shown in FIG. 1. Examples of these accessories include a gun in the turret of a tank, a bucket on a front-end loader, or forks on a fork lift.

An embodiment of the present invention comprising a miniature bulldozer further includes a ripper 112. Figures 5A and 5b illustrate the ripper 112 shown in FIG. 1. The ripper 112 shown in FIG. 5A is an example of a multi-shank ripper, comprising dual shanks. The ripper 112 is attached a to an end of the outer member 501 of parallelogram ripper arm 113.

In FIG. 5B ripper arm 113 comprises four members, which are attached to form a parallelogram arm. Members opposite one another remain in parallel throughout the arm's motion. Multi-shank ripper 112 is rigidly attached to member 501. Member 502 is attached to the frame of the machine and remains in parallel with member 501. Members 503 and 504 form the top and bottom of the ripper arm and are attached to member 502 at one end and member 501

at the other. Members 503 and 504 may be separated to provide stability to the arm. In an embodiment of the present invention, members 503 and 504 are duplicated on an opposite side of members 501 and 502 to provide further stability. Ripper 112 and/or ripper arm 113 is attached to the hydraulic system to facilitate raising and lowering of the ripper 112.

In embodiments of the present invention, the miniature vehicle includes interchangeable shells or bodies. FIG. 6A illustrates an embodiment of the present invention as a bulldozer. To attach bulldozer body 610 to the frame of the vehicle, predrilled holes 601 and 603 in bulldozer body 114 are aligned with holes 602 and 604 in the frame. Fasteners, such as allen-head screws, are then inserted through the holes to attach the body 610 to the frame.

FIG 6B illustrates a tank body 605. Tank body 605 comprises two holes 606 and 607 that align with holes 602 and 604 respectively. As such, one body can be easily removed from the frame and a different body attached in its place. Other embodiments include bodies of, for example, a crane, a truck, a forklift, a front-end loader, and an armored personnel carrier.

Embodiments of the present invention include elements that add aspects of a life-size vehicle to a miniature, scale-size vehicle and provide useful functions for work activities. For example, an embodiment may include a sound module and lighting accessories. These features allow a miniature vehicle to light a work area and to communicate with a dangerous person in a hazardous environment.

An embodiment of the present invention includes a miniature wireless video camera mounted on the frame. A video camera provides a person operating the vehicle with a view that approximates the view an operator of a full-scale vehicle has. A camera provides the person operating the vehicle in a hazardous situation with a means of viewing situations encountered by the machine without subjecting the person operating the machine to the hazard.

An embodiment of the present invention further comprises weapons, detectors, sensors, and sample gathering devices, which enhance the work capabilities of the vehicle in hazardous situations. For example, an embodiment comprises a device to deliver tear gas and/or an infrared sensor capable of helping police assess and intervene in a potentially dangerous situation. Additionally, a vehicle designed to perform land mine detection and removal comprises land mine detectors and/or pre-detonation devices.

An embodiment of the present invention comprises a kit. In one embodiment, the kit includes all of the materials necessary to assemble a complete vehicle, such as a bulldozer. In another embodiment, the kit includes a single sub-system of a vehicle. For example, one kit includes a frame and a propulsion system. A second kit includes a single hydraulic system. In order to assemble a complete bulldozer, including a bulldozer blade 110 and ripper 112, one frame and propulsion kit and two hydraulic system kits are used.

Other kits according to the present invention include a radio-control system. In an embodiment of the present invention as a bulldozer, the kit includes a four-channel radio. The kit also includes a electronic speed control to control each of the two electric propulsion motors 201a, b and two servos to control each of the two hydraulic systems for the bulldozer blade 110 and ripper arm 112. In such an embodiment, forward and backward movements of a control stick on the transmitter control the speed and direction of movement of the corresponding track. Left and right movements of a control stick cause operation of a hydraulic system.

The foregoing description of the preferred embodiments of the invention has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Numerous modifications and adaptations

thereof will be apparent to those skilled in the art without departing from the spirit and scope of the present invention.